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DUANE ARNOLD ENERGY CENTER
CEDAR RIVER OPERATIONAL ECOLOGICAL STUDY
ANNUAL REPORT

January 1985 - December 1985

Submitted by

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INTRODUCTION

This report presents the results of the physical, chemical, and biological studies of the Cedar River in the vicinity of the Duane Arnold Energy Center during the 12th year of station operation (January 1985 to December 1985).

The Duane Arnold Energy Center Operational Study was implemented in mid-January 1974. Prior to plant start-up, extensive pre-operational data were collected, beginning in April 1971. These pre-operational studies provided a substantial amount of "baseline" data with which to compare the information collected since the station became operational. The availability of 12 years of operational data, collected under a variety of climatic and hydrological conditions, provides an excellent basis for the assessment of the effects of the operation of the Duane Arnold Energy Center on the limnology and water quality of the Cedar River. Equally important is the availability of sufficient data to identify long-term trends in the water quality of the Cedar River which are unrelated to station operation, but are indicative of climatic patterns, changes in land use practices or pollution control procedures within the Cedar River basin.

SITE DESCRIPTION

The Duane Arnold Energy Center, a nuclear fueled electrical generating plant, operated by the Iowa Electric Light and Power Company, is located on the west side of the Cedar River, about two and one-half miles north-northeast of Palo, Iowa, in Linn County. The plant employs a boiling water nuclear power reactor which produces approximately 560 MWe of power at full capacity. Waste heat rejected from the turbine cycle to the condenser circulating water is removed by two closed loop induced draft cooling towers, which require a maximum of 11,000 gpm (about 24.5 cfs) of water from the Cedar River. A maximum of 7,000 gpm (about 15.5 cfs) may be lost through evaporation, while 4,000 gpm (about 9 cfs) may be returned to the river as blowdown water from the cool side of the cooling towers.

OBJECTIVES

Studies to determine the baseline physical, chemical, and biological characteristics of the Cedar River near the Duane Arnold Energy Center prior to plant start-up were instituted in April of 1971. These pre-operational studies are described in earlier reports.[1-3] Data from these studies served as a basis for the development of the operational study.

The operational studies were designed to identify and evaluate any significant effects of chemical or thermal discharges from the generating station into the Cedar River, as well as assess the magnitude of impingement of the fishery on intake screens or entrainment in the condenser make-up water, and were first implemented in January 1974.[4-14]

The specific objectives of the operational study are twofold:

1. To continue routine water quality determinations in the Cedar River in order to identify any conditions which could result in environmental or water quality problems.
2. To conduct physical, chemical, and biological studies in and adjacent to the discharge canal and to compare the results with similar studies above the intake. This will make possible the determination of any water quality changes occurring as a result of chemical additions or condenser passage, and to identify any impact of the plant effluent on aquatic communities adjacent to the discharge.

STUDY PLAN

During the operational phase of the study, sampling sites were established in the discharge canal and at four locations in the Cedar River (Figure 1): (1) upstream of the plant at the Lewis Access Bridge (Station 1); (2) directly above the plant intake (Station 2); (3) at a point approximately 140 feet below the plant discharge (Station 3); and (4) adjacent to Comp Farm, about one-half mile below the plant (Station 4). Samples are also taken from the discharge canal (Station 5).

Prior to 1979, samples were collected and analyzed by the Department of Environmental Engineering, University of Iowa. From January 1979, through December 1983, samples were collected and analyzed by Ecological Analysts, Inc. Since 1984, collection and analysis of samples has been conducted by the University of Iowa Hygienic Laboratory, located in Iowa City, Iowa. The conclusions contained in this annual report are based on the results of their analysis.

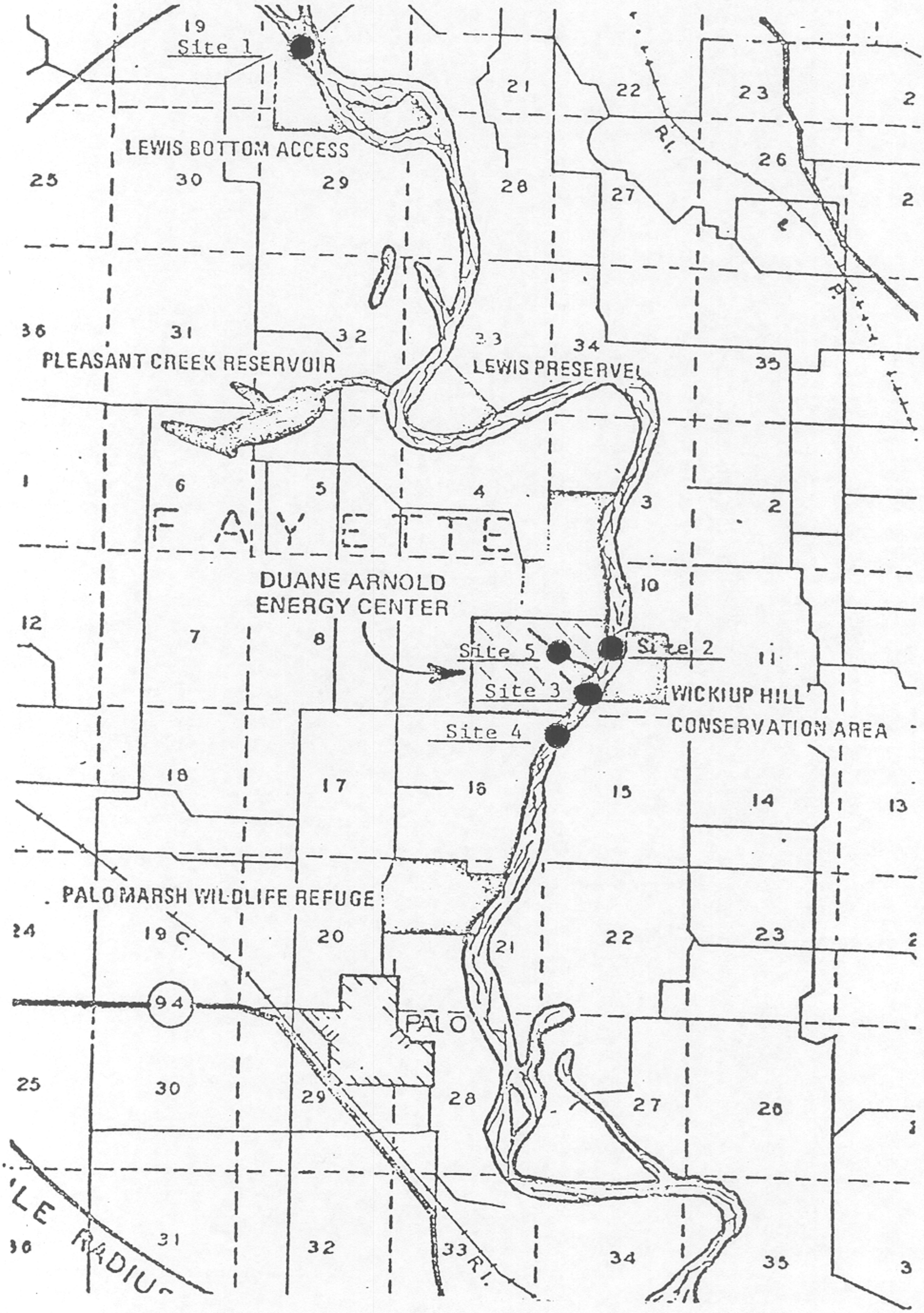

Figure 1. Location of Operational Sampling Sites

Samples for general chemical, physical, and biological analysis were taken twice per month, while other studies were conducted seasonally. The folowing studies are discussed in this report:

I. General Water Quality Analysis

A. Frequency: Twice per month

B. Location: At all five stations

C. Parameters measured:

1. Temperature
2. Turbidity
3. Solids (total, dissolved and suspended)
4. Dissolved Oxygen
5. Carbon Dioxide
6. Alkalinity (total and carbonate)
7. pH
8. Hardness Series (total and calcium)
9. Phosphate Series (total and ortho)
10. Ammonia
11. Nitrate
12. Iron
13. Biochemical Oxygen Demand
14. Coliform Series (total and fecal)

II. Additional Chemical Determinations

A. Frequency: Quarterly

B. Location: At all five stations

C. Parameters measured:

1. Chromium
2. Copper
3. Lead
4. Manganese
5. Mercury
6. Zinc
7. Chloride
9. Sulfate

III. Biological Studies

A. Benthic Studies

1. Frequency: Summer and fall

2. Location: All stations

B. Impingement Studies

1. Frequency: Daily

2. Location: Intake structure

C. Asiatic Clam (Corbicula) Survey

1. Frequency: Three times yearly

2. Location: Upstream and downstream of station, intake bay, and cooling tower basin.

OBSERVATIONS

Physical Conditions

Hydrology (Table 1)

Mean monthly flows in the Cedar River during the period January-December 1985, exhibited considerable variation, ranging from 475% of the median monthly discharge in January to 41% in July. Overall flows were lower than those of 1984. Estimated mean flow for the year was ca. 3,250 cfs, substantially below the 14 year average flow of ca. 5,100 cfs. Mean monthly discharges at the Cedar Rapids gauging station ranged from 876 cfs in August to 7,569 cfs in March. Discharges were classified as excessive (greater than the 75% quartile) in January and February, and from October through December, but were considered deficient (below the 25% quartile) from June through August.

High late winter flows were observed in late February and early March 1985. The maximum yearly flow of 17,800 cfs occurred on February 22. Spring flows were near or somewhat below normal, ranging from ca. 8,000 cfs in early April to 1,700 cfs in early June. Extremely dry conditions during the summer resulted in substantially lower river stages in July and August. A low flow for the year of 770 cfs occurred on August 21. Fall and early winter 1985 flows were generally above normal, ranging from 1,090 to 4,850 cfs. Hydrological data are summarized in Table 1.

Temperature (Table 2)

Ambient river temperatures during the period ranged from 0.0°C (32.0°F) to 26.8°C (80.2°F). The maximum ambient temperature observed upstream of the intake (Station 2) on August 7 was somewhat lower than those of previous years. The maximum downstream temperature of 27.1°C (80.7°F) was observed in the mixing zone (Station 3) on the same date. The highest discharge canal (Station 5) temperature observed during the period, 30.0°C (86.0°F), was recorded on September 4. The Duane Arnold Energy Center was off-line from February 2 through July 18, and as a result, temperature differentials between upstream and downstream locations were minimal during that period. Even during periods of station operation, temperature differentials were usually relatively small. A maximum temperature differential (ΔT value) between the upstream river and the discharge canal (Station 2 vs. Station 5) of 13.0°C (23.4°F) was observed on December 10.

Maximum ΔT values between ambient upstream temperatures (Station 2) and the downstream station (Station 3), located in the mixing zone for the discharge canal, of 3.0°C (5.4°F) were measured on August 21, November 5, and December 10. Maximum temperature elevation at the Comp Farm station, one-half mile below the plant (Station 2 vs. Station 4) of 5.0°C (9.0°F) was observed on December 10. Temperatures at Station 4 were actually lower than those observed upstream in over 60% of the samples during 1985. Over 50% of the samples taken at Station 4 while the station was operational also exhibited negative temperature differentials. A summary of water temperature differentials between upstream and downstream locations is given in Table 3.

Turbidity (Table 4)

Turbidity values were somewhat lower and exhibited less variation than during the previous year. Peak values of 110 NTU occurred at all river locations during early March. Minimum turbidity values of 2 NTU were observed in the river in December. Turbidity values in the discharge canal were usually similar to those observed in river samples.

Solids (Tables 5-7)

Solids determinations included total, dissolved, and suspended. Total solids values in upstream river samples exhibited less variation than those of the previous year. Values ranged from 290 to 550 mg/L, with the majority falling between 400 and 450 mg/L.

In spite of low river flow, dissolved solids values were relatively low throughout the period. Upstream values ranged from 110 mg/L during a period of very high stream flow in March, to 430 mg/L in October. Downstream dissolved solids values at Station 3, 140 feet downstream of the discharge canal, were occasionally higher than upstream values observed above the discharge canal. A maximum downstream value of 560 mg/L was observed at this location on August 21. Dissolved solids values at Station 4, one-half mile below the plant, were generally similar to upstream levels.

Suspended solids values in the river were usually relatively low, ranging from <1 to 290 mg/L. Low values occurred in February and December, while high values occured in March.

Due to concentration in the blowdown, total and dissolved solids values in the discharge canal were frequently higher than in the river samples during periods of station operation. A maximum total solids concentration of 1,500 mg/L was observed in the discharge canal in October, while a minimum value 310 mg/L was observed in March when the station was not operating.

Chemical Conditions

Dissolved Oxygen (Table 8)

Dissolved oxygen concentrations in the river during 1985 ranged from 7.4 to 14.6 mg/L (88 to 100% saturation). Concentrations in the river rarely dropped below 10 mg/L, and were usually in excess of saturation from April through September. A maximum oxygen saturation value of 154% was observed upstream of the plant on August 7. Unlike the previous year, high dissolved oxygen concentrations associated with photosynthetic activity were common. This is not surprising considering the low summer river flows, which contributed to increased algal activity. The highest dissolved oxygen values (ca. 13 to 14.6 mg/L), however, occurred during December, when water temperatures were low and the solubility of the gas was increased. Dissolved oxygen concentrations in the discharge canal (Station 5) ranged from 5.3 to 29.0 mg/L. The latter value was in excess of 280% saturation, and was observed in April, when flow in the discharge canal was reduced, allowing for the development of a large algal population.

Carbon Dioxide (Table 9)

Carbon dioxide concentrations ranged from <1 to 33 mg/L. Highest values occurred during the winter period, while values of <1 mg/L occurred from mid-April through early October.

Alkalinity, pH, Hardness (Tables 10-14)

These parameters are closely related and were influenced by hydrological, climatic, and biological conditions. The highest total alkalinity values observed in the river (ca. 230-290 mg/L) occurred during the late fall and winter. Extremely low values (ca. 60-70 mg/L) occurred in early March, accompaning the period of snowmelt and runoff.

Carbonate alkalinlity was observed in most river samples from mid-April through September, at levels ranging from 2-24 mg/L. This was in marked contrast to 1984, when nearly all river carbonate alkalinity values were below 1 mg/L. The extended presence of carbonate in the river appeared to be related to low river flows and subsequent periods of high photosynthesis.

Values for pH in river samples ranged from 7.4 in December to 9.4 in September. As in previous years, high values coincided with periods of incresed photosynthetic activity in the summer, while low values occurred during the winter period. pH values in the discharge canal ranged from 7.2 to 9.0.

Total hardness values in the upstream river generally paralleled total alkalinity levels, with highest values (340-460 mg/L) occurring in December. A low value of 115 mg/L was observed upstream of the station in early March. Hardness values in the discharge canal and downstream of the station were frequently higher than upstream river values during periods of station operation, a result of reconcentration in the blowdown. Total hardness levels in the discharge canal ranged from 165 to 900 mg/L.

Phosphates (Tables 15 and 16)

Total phosphate concentration in upstream river samples were similar to those observed during 1984. Concentrations ranged from 0.13 mg/L in November to 0.70 mg/L in March, during a period of high river flow. Phosphate levels remained relatively constant during low flow periods in the summer, ranging from ca. 0.25 to 0.40 mg/L. Levels in the discharge canal and the downstream river were frequently higher during periods of station operation. Maximum values of 1.1 and 0.84 mg/L were observed in the discharge canal and the mixing zone, respectively.

Orthophosphate concentrations in river samples ranged from <0.01 mg/L in May and August to a maximum value of 0.34 mg/L in February. As in previous years, reduced orthophosphate concentrations frequently coincided with large plankton populations as a result of uptake by algae.

Ammonia (Table 17)

Average ammonia nitrogen concentrations in the river continued to be relatively low during 1985, ranging from <0.01 to 0.53 mg/L. Highest concentrations accompanied snowmelt and high flows in late February and early March. Low values of <0.01 were common at intervals during the summer and fall when flows were low and large algal populations were present.

Nitrate (Table 18)

The trend in steadily increasing nitrate nitrogen concentrations which began in 1978 and persisted through 1983 appears to have been reversed during 1984 and 1985. During the current year, nitrate nitrogen values in river samples ranged from ca. <0.1 mg/L in August to 10.0 mg/L in December. The average nitrate nitrogen concentration at Station 1, located at Lewis Access upstream of the plant, was 4.8 mg/L. This was the lowest average flow since 1978, and compares to an average value of 8.6 mg/L in 1983. Nitrate nitrogen concentrations were below 1 mg/L in all river samples collected from mid-July through early September, when river flows were low. Nitrate concentrations were frequently higher in the discharge canal than in river samples during periods of station operation, due to reconcentration in the blowdown. A maximum nitrate nitrogen concentration of ca. 16 mg/L was observed in the discharge canal in December.

Iron (Table 19)

Maximum iron concentrations in the river were substantially lower than those observed in 1984. River iron values in 1985 ranged from 0.10 to 5.2 mg/L. Highest concentrations occurred in early March, in conjunction with high river flow. Low values occurred during December. High iron concentrations are frequently observed in association with high turbidity values and high flows, indicating that most of the iron present is in the suspended form rather than in solution. During the low flow period in July and August 1985, ambient river iron levels never exceeded 0.6 mg/L. Iron levels were frequently higher in the discharge canal than in the river samples.

Biological Conditions

Biochemical Oxygen Demand (Table 20)

Average five-day biochemical oxygen demand (BOD_5) values were the highest observed since 1976. Levels in the river ranged from <1 to 27 mg/L. Relatively high values (7-8 mg/L) were associated with late winter runoff in early March, but otherwise the winter and early spring period was characterized by low BOD levels of 3 mg/L or less. High BOD values, ranging from 7 to 27 mg/L, were consistently observed from early June through mid-September as a result of low river flow and accompaning large algal populations.

Coliform Organisms (Tables 21 and 22)

Determination of total and fecal coliform bacterial populations were reinstituted in 1984 after being discontinued in 1978. Average coliform values were somewhat lower than those observed during 1984, likely due to the lower river flows present in 1985. In general, the highest counts occurred during the fall and winter periods. Maximum total and fecal coliform counts of 19,000 and 3,800 organisms/100 ml, respectively, were observed on January 24. Low total and fecal coliform counts of 10 to 100 organisms/100 ml were observed during periods of low flow in the summer.

ADDITIONAL STUDIES

In addition to the routine monthly studies, a number of seasonal limnological and water quality investigations were conducted during 1985. The studies discussed here include additional chemical determinations, benthic and impingement studies, and an Asiatic clam (Corbicula) survey.

Additional Chemical Determinations

Samples for additional chemical determinations were collected on February 4, May 1, July 15, and October 2 and analyzed for chlorides, sulfates, chromium, copper, lead, manganese, mercury, and zinc. In general, concentrations fell within the expected ranges and were similar to those observed during 1984.

Concentrations of most heavy metals in the 1985 samples were relatively low throughout the year, and no violations of water quality standards were observed.[15] Little variation was present between locations. Highest zinc concentrations (30-80 μg/L) were observed during July, when river flow was low. Relatively high manganese levels (950 g/L) were observed upstream of the plant (Station 1) in October, but the cause of this high value was not determined. Values for other heavy metals were below the detection limit in all samples.

Concentrations of chloride and sulfate were within the expected ranges. Reconcentration of solids in the cooling tower blowdown resulted in elevated manganese, chloride, and sulfate concentrations in the October discharge canal samples. The results of the additional chemical determinations are given in Table 23.

Benthic Studies

Bottom samples were taken at two locations, upstream and downstream of the station, in June and November, by means of a Ponar dredge. No organisms were found in the June samples and only three chironomid larvae were found in the November samples. Although these numbers appear extremely low, they are generally compatible with earlier studies which indicate that the shifting sand and silt bottom supports a benthic community of very limited size and diversity.

Three artificial substrates (Hester-Dendy) were placed at each station upstream and downstream of the station and in the discharge canal in June and September, and collected in July and October, respectively. As in previous years, substrate samples were characterized by greater numbers and species diversity than the natural substrate (Ponar dredge) samples. A total of 28 taxa were identified. No major seasonal differences were apparent. Discharge canal samples were dominated by midge (chironomid) larvae, while caddisfly (tricoptera) larvae were the most abundant organisms on the river substrates. During the summer, chironomid larvae and mayfly (ephemeroptera) nymphs were also common. In general, there was little difference in the size or composition of benthic populations between upstream and downstream locations.

As in previous years, the artificial substrate studies indicate the Cedar River, both upstream and downstream of the Duane Arnold Energy Center, is capable of supporting a relatively diverse macroinvertebrate fauna in those limited areas where suitable bottom habitat is available. The results of the benthic studies are given in Table 24.

Impingement Studies

The total numbers of fish impinged on the intake screens at the Duane Arnold Energy Center during 1985 were similar to those observed in 1984. Although both years exhibited somewhat slightly higher levels than those of previous years, numbers are still surprisingly low. Daily counts conducted by DAEC station personnel indicate a total of 795 fish were impinged during 1985. Highest impingement rates continued to occur during the winter. During the months of January, February, November, and December, 674 fish were removed from the trash baskets. The month with the highest impingement rate was November, when 454 fish were collected in the trash baskets. The results of the daily trash basket counts are given in Table 25.

Asiatic Clam Survey

In recent years several power generation facilities have experienced problems with blockage of cooling water intake systems by large numbers of Asiatic clams (*Corbicula* sp.). Although this clam is common in portions of the Iowa reach of the Mississippi River, it is normally absent from areas with shifting sand/silt substrates such as occur in the Cedar River in the vicinity of the Duane Arnold Energy Center. *Corbicula* has not been collected from the Cedar River in the vicinity of the DAEC during the routine Cedar River monitoring program, which was implemented in April of 1971. A single *Corbicula* was, however, collected in January of 1979 in the vicinity of Lewis Access, upstream of DAEC, by Hazelton personnel. Because *Corbicula* has been collected on one occasion from the Cedar

River and is commonly found in power plant intakes on the Mississippi River, studies were implemented at the Duane Arnold Energy Center in 1981 in order to determine if the organism had established itself within the system. No *Corbicula* were collected during the 1981, 1982, 1983, or 1984 investigations.

The *Corbicula* surveys conducted during 1985 continued to be negative. Samples were taken on June 17, September 25, and November 5, 1985. During the June and September surveys, 10 Ponar dredge samples were collected in the area between the bar screens and the traveling screens at the intake. Additional dredge samples, two in the discharge canal and in each of the cooling tower exit basins, were also collected in September. Dredge samples were collected from the river in November. No Asiatic clams were identified from the samples. Visual inspections of the shoreline along the river and discharge canal and around the base of the cooling towers did not indicate the presence of any of these organisms.

DISCUSSION AND CONCLUSIONS

Flows in the Cedar River during 1985 were significantly lower than those of recent years. The 1985 mean flow of ca. 3,250 cfs was the lowest observed since 1977, and the third lowest annual mean flow since the inception of the Cedar River Water Quality Study in 1971. Mean discharge in the Cedar River was well below normal during the period April to September, 1985, which would normally provide an excellent opportunity to assess the effects of station operation on the limnology and water quality of the river. However, the Duane Arnold Energy Center was not in operation from February through mid-July 1985, and as a result, differences in both temperature and water quality characteristics upstream and downstream of the station were minimal during the period.

Although the station was operating at between 85 and 96% of capacity during August and September, when mean flows were below normal, temperature and water quality characteristics downstream of the discharge were not markedly different under those conditions than those present upstream. During the August-September period a maximum temperature differential (ΔT) of $3^{\circ}C$ ($5.4^{\circ}F$) was observed between the river upstream of the plant (Station 2) and the mixing zone (Station 3), while observed temperature differentials one-half mile below the plant (Station 4) never exceeded $1^{\circ}C$ ($1.8^{\circ}F$). Other parameters which might be expected to increase downstream of the plant exhibited moderate increases during the period. Maximum increases in dissolved solids and total hardness of 60 and 70 mg/L (30 and 41%), respectively, were observed at Station 4, one-half mile below the plant, but no violations of water quality standards occurred.

Operation of the Duane Arnold Energy Center appeared to have little effect on the river biota. Fish impingement rates remained low during 1985, and benthic communities upstream and downstream of the station were similar to one another and representative of the habitat conditions present.

Although station operation had little effect on the limnology or water quality of the river, the effects of the low flow present during much of the period were evident. In general, levels of those parameters normally associated with runoff from the drainage basin, such as turbidity, suspended solids, total phosphates, ammonia, iron, and coliform organisms, remained relatively constant throughout most of the year.

Highest levels of these parameters usually occurred during high flow periods in February and March. Reduced river flow also contributed to the decline in nitrate concentrations, which reached their lowest annual level since 1978 (Table 26). Minimal nitrate concentrations of less than 0.5 mg/L (as N) were observed in mid-July and August in conjunction with an extended period of extremely dry weather and low river flow. Low nitrate concentrations were observed in the Iowa River, which also exhibited unusually low flow during 1985.[16] The effects of reduced runoff and low river discharge are especially apparent when the 1985 relative loading values (obtained by multiplying average annual concentration by cumulative yearly runoff) for several parameters are compared with those of earlier years (Table 27).

Low flow conditions were also indirectly responsible for the high dissolved oxygen, carbonate, pH, and BOD levels as well as low orthophosphate concentrations observed in the Cedar River during the summer of 1985. The abovementioned conditions were all related to increased algal activity, which is normally enhanced by warm, sunny weather, and reduced river flow.

In summary, it appears that during 1985, as in previous years, the water quality and limnology of the Cedar River is influenced to a far greater extent by agricultural activities and by climatological and hydrological conditions than by municipal or industrial discharges. Operation of the Duane Arnold Energy Center continues to have a minimal effect on the Cedar River.

Table 1

Summary of Hydrological Conditions
Cedar River at Cedar Rapids*
1985

Date	Mean Monthly Discharge (cfs)	Percent of 1951-1980 Median Discharge
January	3,443	329
February	5,769	475
March	7,569	143
April	4,892	84
May	2,803	67
June	2,097	49
July	1,346	41
August	876	43
September	1,726	97
October	3,940	264
November	3,096	168
December	2,881	230

*Data obtained from U.S. Geological Survey records

Table 2

Temperature (C^o) Values from the Cedar River Near the Duane Arnold Energy Center During 1985

Date 1985	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
	Sampling Locations				
Jan 08	0.0	0.5	0.0	0.0	0.0
Jan 24	0.0	0.5	2.0	1.0	0.0
Feb 04	0.0	0.0	1.0	0.0	0.0
Feb 18	0.0	0.0	2.0	0.0	0.0
Mar 06	1.0	1.0	2.0	1.0	0.0
Mar 18	6.0	6.0	11.0	6.5	6.0
Apr 03	8.5	9.0	13.0	9.0	8.5
Apr 15	13.5	14.0	15.0	14.0	13.0
May 01	16.5	17.0	18.5	17.0	16.0
May 15	17.5	17.0	17.0	17.0	16.5
Jun 03	18.0	19.0	19.0	21.5	21.0
Jun 17	21.0	22.0	22.0	21.5	21.0
Jul 02	25.0	26.0	25.0	26.0	25.0
Jul 15	26.0	25.5	23.0	25.0	25.0
Aug 07	26.0	26.8	28.0	27.1	25.1
Aug 21	20.0	20.0	26.0	23.0	19.9
Sep 04	25.0	25.5	30.0	23.0	24.5
Sep 18	22.2	22.3	29.0	25.0	22.5
Oct 02	9.7	10.2	21.4	13.1	10.0
Oct 16	11.3	12.0	12.0	12.0	11.0
Nov 05	6.0	6.0	16.0	9.0	6.0
Nov 19	2.0	6.0	11.0	7.0	5.0
Dec 10	0.0	0.0	13.0	3.0	5.0
Dec 18	0.0	0.0	1.0	1.0	1.0

Table 3

Summary of Water Temperature Differentials and Station Output During Periods of Cedar River Sampling During 1985

Date	ΔT (°C) U/S River (Sta. 2) vs. Discharge Canal (Sta. 5)	ΔT (°C) U/S River (Sta. 2) vs. D/S River (Sta. 3)	ΔT (°C) U/S River (Sta. 2) vs. D/S River (Sta. 4)	Station Output (% full power)
Jan 08	-0.5	-0.5	-0.5	65
Jan 24	1.5	1.5	-0.5	66
Feb 04	1.0	0.0	0.0	0
Feb 18	2.0	0.0	0.0	0
Mar 06	1.0	0.0	-1.0	0
Mar 18	5.0	0.5	0.0	0
Apr 03	4.0	0.0	-1.5	0
Apr 15	1.0	0.0	-1.0	0
May 01	1.5	0.0	-1.0	0
May 15	0.0	0.0	-0.5	0
Jun 03	0.0	2.5	2.0	0
Jun 17	0.0	-0.5	-1.0	0
Jul 02	-1.0	0.0	-1.0	0
Jul 15	-1.5	-0.5	-0.5	0
Aug 07	1.2	0.3	-1.7	92
Aug 21	6.0	3.0	-0.1	96
Sep 04	4.5	-1.5	1.0	85
Sep 18	6.7	1.7	0.2	92
Oct 02	11.2	2.9	-0.2	100
Oct 16	0.0	0.0	-1.0	65

Table 3 (cont.)

Date	ΔT (^{o}C) U/S River (Sta. 2) vs. Discharge Canal (Sta. 5)	ΔT (^{o}C) U/S River (Sta. 2) vs. D/S River (Sta. 3)	ΔT (^{o}C) U/S River (Sta. 2) vs. D/S River (Sta. 4)	Station Output (% full power)
Nov 05	10.0	3.0	0.0	67
Nov 19	5.0	1.0	-1.0	49
Dec 10	13.0	3.0	5.0	76
Dec 18	1.0	1.0	1.0	75

Table 4

Turbidity (NTU) Values from the Cedar River
Near the Duane Arnold Energy Center During 1985

Date 1985	Sampling Locations				
	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
Jan 08	6	*	6	5	6
Jan 24	*	3	6	5	6
Feb 04	17	5	2	4	4
Feb 18	4	4	13	4	5
Mar 06	110	110	100	110	110
Mar 18	50	55	38	55	55
Apr 03	28	26	6	26	26
Apr 15	22	22	6	22	22
May 01	36	34	6	36	36
May 15	25	32	21	36	36
Jun 03	48	70	43	64	55
Jun 17	50	45	34	49	51
Jul 02	40	39	27	38	40
Jul 15	31	27	30	30	24
Aug 07	30	28	43	40	34
Aug 21	24	30	65	45	31
Sep 04	36	37	71	55	41
Sep 18	42	49	29	38	48
Oct 02	28	29	73	38	39
Oct 16	32	33	33	32	31
Nov 05	14	15	29	17	15
Nov 19	12	14	30	16	17
Dec 10	3	5	9	3	3
Dec 18	2	3	3	5	4

*Sampling accident.

Table 5

Total Solids (mg/L) Values from the Cedar River Near the Duane Arnold Energy Center During 1985

Date 1985	Sampling Locations				
	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
Jan 08	390	*	380	410	370
Jan 24	*	450	870	470	480
Feb 04	470	450	570	440	440
Feb 18	430	370	410	380	390
Mar 06	410	370	310	390	370
Mar 18	400	400	350	400	400
Apr 03	400	400	380	390	390
Apr 15	440	460	410	410	470
May 01	510	550	350	520	520
May 15	370	360	330	370	360
Jun 03	420	420	360	390	400
Jun 17	480	460	380	450	470
Jul 02	420	400	374	410	400
Jul 15	360	330	360	340	320
Aug 07	310	320	980	650	370
Aug 21	290	320	1100	720	360
Sep 04	340	360	1000	580	410
Sep 18	370	350	1200	340	430
Oct 02	430	430	1500	590	480
Oct 16	550	520	530	530	550
Nov 05	450	440	750	450	450
Nov 19	410	390	1300	460	420
Dec 10	420	530	1400	460	430
Dec 18	400	400	830	460	430

*Sampling accident.

Table 6

Dissolved Solids (mg/L) Values from the Cedar River
Near the Duane Arnold Energy Center During 1985

Date 1985	Sampling Locations: Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
Jan 08	360	340	340	380	320
Jan 24	400	410	760	450	400
Feb 04	410	400	490	400	400
Feb 18	370	330	270	340	350
Mar 06	180	110	100	100	110
Mar 18	240	250	260	270	250
Apr 03	300	300	370	290	290
Apr 15	310	330	350	320	300
May 01	400	400	340	360	390
May 15	250	240	270	260	250
Jun 03	240	240	230	210	220
Jun 17	320	310	290	310	300
Jul 02	310	320	330	300	300
Jul 15	240	230	230	250	230
Aug 07	200	210	820	500	260
Aug 21	210	200	880	560	260
Sep 04	210	210	280	400	270
Sep 18	290	250	1100	240	310
Oct 02	370	360	1350	480	400
Oct 16	430	410	420	420	420
Nov 05	390	390	650	340	370
Nov 19	380	370	1200	450	390
Dec 10	370	*	1300	400	390
Dec 18	390	390	770	430	410

*Laboratory accident

Table 7

Suspended Solids (mg/L) Values from the Cedar River
Near the Duane Arnold Energy Center During 1985

Date 1985	Sampling Locations: Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
Jan 08	16	*	24	18	30
Jan 24	*	22	34	20	14
Feb 04	38	2	2	2	2
Feb 18	8	7	55	7	10
Mar 06	230	260	180	290	250
Mar 18	110	120	62	110	120
Apr 03	93	94	10	87	86
Apr 15	77	78	28	82	79
May 01	81	86	13	76	75
May 15	78	89	62	85	83
Jun 03	170	190	120	160	150
Jun 17	130	120	64	110	130
Jul 02	96	90	38	88	88
Jul 15	110	90	92	78	78
Aug 07	110	90	110	100	90
Aug 21	80	88	150	120	87
Sep 04	110	120	160	140	130
Sep 18	82	86	110	86	88
Oct 02	54	88	120	74	66
Oct 16	88	98	92	110	100
Nov 05	38	34	48	34	22
Nov 19	12	14	30	12	24
Dec 10	6	4	12	2	<1
Dec 18	6	6	12	2	2

*Sampling accident.

Table 8

Dissolved Oxygen (mg/L) Values from the Cedar River
Near the Duane Arnold Energy Center During 1985

Date 1985	Sampling Locations: Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
Jan 08	12.7	12.5	13.8	12.3	12.6
Jan 24	11.0	10.5	11.1	10.6	10.7
Feb 04	12.0	10.6	11.6	10.8	10.5
Feb 18	11.3	11.7	14.0	11.2	11.4
Mar 06	13.8	13.7	13.8	13.0	13.1
Mar 18	11.2	11.3	10.0	11.2	11.4
Apr 03	12.4	12.8	17.3	12.3	12.4
Apr 15	12.2	12.6	29.0	12.3	11.7
May 01	11.3	11.3	11.0	11.5	10.3
May 15	11.0	11.1	10.0	11.1	10.8
Jun 03	13.6	13.4	10.5	12.3	11.9
Jun 17	11.5	11.7	9.7	10.7	11.4
Jul 02	11.3	12.7	8.3	10.5	10.4
Jul 15	11.2	12.4	9.0	11.1	11.3
Aug 07	12.1	12.5	5.9	9.5	10.5
Aug 21	12.8	12.6	7.8	9.6	10.5
Sep 04	7.4	11.4	5.5	8.4	8.3
Sep 18	13.3	13.5	5.3	11.0	12.0
Oct 02	11.0	11.3	7.2	10.4	11.1
Oct 16	10.1	10.0	10.7	10.1	9.2
Nov 05	11.5	11.5	9.0	11.4	11.3
Nov 19	11.4	11.6	9.1	11.1	13.3
Dec 10	14.6	14.1	9.8	12.5	14.4
Dec 18	13.7	13.9	12.9	13.1	13.4

Table 9

Carbon Dioxide (mg/L) Values from the Cedar River
Near the Duane Arnold Energy Center During 1985

	Sampling Locations				
Date 1985	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
Jan 08	8	8	7	7	8
Jan 24	12	11	11	10	11
Feb 04	18	18	11	17	18
Feb 18	11	11	8	11	12
Mar 06	4	4	3	4	7
Mar 18	5	5	5	4	4
Apr 03	2	0	2	0	0
Apr 15	0	0	0	0	0
May 01	<1	<1	2	<1	<1
May 15	<1	<1	2	<1	1
Jun 03	<1	<1	<1	<1	<1
Jun 17	<1	<1	2	<1	<1
Jul 02	<1	<1	4	<1	<1
Jul 15	<1	<1	1	<1	<1
Aug 07	<1	<1	1	<1	<1
Aug 21	<1	<1	<2	<1	<1
Sep 04	<1	<1	1	<1	<1
Sep 18	<1	<1	<1	<1	<1
Oct 02	<1	<1	-	<1	2
Oct 16	3	<1	<1	<1	2
Nov 05	<1	<1	<1	<1	<1
Nov 19	3	3	-	4	3
Dec 10	12	7	3	10	11
Dec 18	22	22	28	27	33

Table 10

Total Alkalinity (mg/L-$CaCO_3$) Values from the Cedar River
Near the Duane Arnold Energy Center During 1985

Date 1985	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
Jan 08	196	206	196	189	196
Jan 24	236	226	204	224	230
Feb 04	230	241	232	232	234
Feb 18	232	229	236	228	235
Mar 06	64	66	69	66	66
Mar 18	152	151	173	152	149
Apr 03	188	186	192	188	180
Apr 15	196	198	220	200	200
May 01	196	198	253	200	199
May 15	156	150	172	164	148
Jun 03	120	104	134	130	104
Jun 17	180	174	182	184	176
Jul 02	162	150	162	152	148
Jul 15	116	110	130	122	112
Aug 07	106	104	96	102	100
Aug 21	119	112	105	105	109
Sep 04	108	105	110	101	100
Sep 18	191	174	90	150	169
Oct 02	206	213	105	196	201
Oct 16	230	233	230	232	232
Nov 05	216	228	349	246	228
Nov 19	218	222	61	207	234
Dec 10	239	290	134	237	258
Dec 18	236	238	170	236	238

Table 11

Carbonate ($mg/L-CaCO_3$) Values from the Cedar River
Near the Duane Arnold Energy Center During 1985

Date 1985	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
	Sampling Locations				
Jan 08	<1	<1	<1	<1	<1
Jan 24	<1	<1	<1	<1	<1
Feb 04	<1	<1	<1	<1	<1
Feb 18	<1	<1	<1	<1	<1
Mar 06	0	0	0	0	0
Mar 18	0	0	0	0	0
Apr 03	<1	2	<1	2	3
Apr 15	6	6	22	8	7
May 01	6	6	0	6	4
May 15	2	2	0	2	0
Jun 03	8	8	1	6	8
Jun 17	5	4	<1	4	4
Jul 02	6	8	<1	2	3
Jul 15	6	7	<1	5	8
Aug 07	10	8	<1	6	6
Aug 21	13	11	<1	*	10
Sep 04	11	13	<1	8	7
Sep 18	24	20	3	20	24
Oct 02	*	*	*	*	*
Oct 16	*	2	<1	<1	<1
Nov 05	8	7	26	10	8
Nov 19	<1	<1	<1	<1	<1
Dec 10	<1	<1	<1	<1	<1
Dec 18	<1	<1	<1	<1	<1

*Sampling accident.

Table 12

Units of pH from the Cedar River
Near the Duane Arnold Energy Center During 1985

Date 1985	Sampling Locations				
	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
Jan 08	7.9	7.9	7.9	7.9	7.9
Jan 24	7.8	7.8	7.7	7.8	7.8
Feb 04	7.6	7.6	7.8	7.6	7.6
Feb 18	7.8	7.8	7.9	7.8	7.8
Mar 06	7.7	7.7	7.7	7.7	7.5
Mar 18	8.0	8.0	7.9	8.0	8.0
Apr 03	8.3	8.4	8.3	8.4	8.4
Apr 15	8.6	8.6	9.0	8.6	8.6
May 01	8.5	8.5	8.3	8.5	8.4
May 15	8.5	8.4	8.2	8.4	8.3
Jun 03	9.0	8.9	8.5	8.8	8.9
Jun 17	8.6	8.5	8.3	8.5	8.5
Jul 02	8.7	8.6	7.9	8.4	8.5
Jul 15	8.7	8.9	8.4	8.7	8.8
Aug 07	9.2	9.1	8.1	8.8	8.9
Aug 21	9.0	9.0	8.1	8.4	9.0
Sep 04	8.8	8.9	8.2	8.6	8.6
Sep 18	9.2	9.4	8.4	9.3	9.1
Oct 02	8.6	8.5	8.1	8.5	8.4
Oct 16	8.3	8.4	8.5	8.4	8.2
Nov 05	8.6	8.6	8.8	8.7	8.6
Nov 19	8.3	8.3	7.5	8.2	8.2
Dec 10	7.8	8.1	7.9	7.8	7.8
Dec 18	7.5	7.5	7.2	7.4	7.4

Table 13

Total Hardness (mg/L-$CaCO_3$) Values from the Cedar River
Near the Duane Arnold Energy Center During 1985

	Sampling Locations				
Date 1985	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
Jan 08	260	280	270	280	270
Jan 24	320	310	540	330	310
Feb 04	330	320	360	320	350
Feb 18	300	290	300	300	290
Mar 06	130	115	200	195	185
Mar 18	210	195	220	215	210
Apr 03	265	279	296	237	257
Apr 15	272	288	292	294	270
May 01	270	270	270	280	280
May 15	220	225	225	220	220
Jun 03	170	165	183	175	160
Jun 17	230	230	230	240	240
Jul 02	210	190	210	210	210
Jul 15	160	160	165	160	155
Aug 07	160	170	550	320	240
Aug 21	170	150	580	380	180
Sep 04	140	160	460	250	170
Sep 18	210	210	690	365	245
Oct 02	290	280	870	360	300
Oct 16	310	320	315	310	315
Nov 05	320	300	510	330	300
Nov 19	292	292	820	330	315
Dec 10	340	460	900	440	380
Dec 18	312	316	584	376	296

Table 14

Calcium Hardness (mg/L-$CaCO_3$) Values from the Cedar River
Near the Duane Arnold Energy Center During 1985

Date 1985	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
	Sampling Locations				
Jan 08	185	185	190	200	180
Jan 24	210	210	320	220	210
Feb 04	210	220	240	230	210
Feb 18	190	190	190	200	190
Mar 06	75	90	100	95	90
Mar 18	150	150	165	130	140
Apr 03	190	195	205	192	198
Apr 15	185	195	200	185	185
May 01	205	180	165	180	185
May 15	130	130	140	130	130
Jun 03	78	73	73	80	78
Jun 17	150	140	140	140	140
Jul 02	130	120	130	130	130
Jul 15	75	75	83	73	73
Aug 07	55	60	220	130	150
Aug 21	75	70	580	180	85
Sep 04	70	75	250	130	80
Sep 18	130	130	425	130	150
Oct 02	190	180	560	230	190
Oct 16	205	200	210	195	205
Nov 05	190	170	350	150	110
Nov 19	187	187	531	214	194
Dec 10	260	300	595	245	290
Dec 18	205	240	390	230	260

Table 15

Total Phosphorus (mg/L-P) Values from the Cedar River
Near the Duane Arnold Energy Center During 1985

Date 1985	Sampling Locations				
	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
Jan 08	0.35	*	0.38	0.34	0.35
Jan 24	*	0.21	0.23	0.22	0.24
Feb 04	0.36	0.29	0.28	0.31	0.24
Feb 18	0.32	0.36	0.31	0.28	0.27
Mar 06	0.67	0.70	0.63	0.70	0.70
Mar 18	0.38	0.36	0.27	0.36	0.38
Apr 03	0.33	0.28	0.12	0.29	0.28
Apr 15	0.24	0.24	0.31	0.25	0.25
May 01	0.31	0.31	0.29	0.33	0.32
May 15	0.24	0.20	0.19	0.20	0.19
Jun 03	0.36	0.38	0.31	0.34	0.36
Jun 17	0.27	0.35	0.22	0.31	0.27
Jul 02	0.26	0.26	0.59	0.31	0.23
Jul 15	0.38	0.36	0.70	0.47	0.39
Aug 07	0.25	0.23	0.66	0.43	0.28
Aug 21	0.32	0.32	0.78	0.56	0.36
Sep 04	0.41	0.43	0.74	0.55	0.51
Sep 18	0.16	0.29	0.30	0.84	0.48
Oct 02	0.34	0.30	0.66	0.50	0.33
Oct 16	0.25	0.26	0.28	0.26	0.27
Nov 05	0.18	0.20	0.46	0.16	0.13
Nov 19	0.14	0.16	1.1	0.22	0.18
Dec 10	0.23	0.26	0.55	0.25	0.26
Dec 18	0.31	0.34	0.59	0.38	0.40

*Laboratory accident

Table 16

Soluble Orthophosphate (mg/L-P) Values from the Cedar River Near the Duane Arnold Energy Center During 1985

Date 1985	Sampling Locations: Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
Jan 08	0.18	0.17	0.16	0.21	0.17
Jan 24	*	0.20	0.23	0.22	0.24
Feb 04	0.34	0.26	0.21	0.27	0.24
Feb 18	0.27	0.26	0.27	0.27	0.27
Mar 06	0.27	0.26	0.33	0.27	0.27
Mar 18	0.17	0.18	0.18	0.18	0.16
Apr 03	0.09	0.09	0.01	0.09	0.08
Apr 15	0.06	0.07	0.03	0.07	0.07
May 01	0.08	0.09	0.12	0.09	0.10
May 15	<0.01	<0.01	<0.01	<0.01	<0.01
Jun 03	0.06	0.04	0.09	0.05	0.05
Jun 17	0.06	0.05	0.06	0.05	0.07
Jul 02	0.04	0.03	0.11	0.05	0.05
Jul 15	0.05	0.05	0.08	0.07	0.06
Aug 07	0.02	0.01	0.13	0.06	0.03
Aug 21	0.03	0.04	0.14	0.08	0.05
Sep 04	0.10	0.03	0.26	0.09	0.02
Sep 18	<0.01	<0.01	0.24	0.04	<0.01
Oct 02	0.18	0.18	0.54	0.28	0.21
Oct 16	0.13	0.13	0.14	0.13	0.13
Nov 05	0.04	0.04	0.14	0.05	0.04
Nov 19	0.07	0.06	0.47	0.11	0.08
Dec 10	0.18	0.22	0.38	0.21	0.22
Dec 18	0.17	0.17	0.33	0.19	0.19

*Sampling accident.

Table 17

Ammonia (mg/L-N) Values from the Cedar River
Near the Duane Arnold Energy Center During 1985

Date 1985	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
	Sampling Locations				
Jan 08	0.24	0.32	0.25	0.26	0.26
Jan 24	*	0.33	0.09	0.31	0.31
Feb 04	0.41	0.38	0.23	0.38	0.37
Feb 18	0.46	0.48	0.46	0.46	0.46
Mar 06	0.53	0.52	0.50	0.51	0.52
Mar 18	0.24	0.25	0.29	0.24	0.25
Apr 03	<0.01	<0.01	<0.01	<0.01	<0.01
Apr 15	<0.01	<0.01	<0.01	<0.01	<0.01
May 01	0.02	0.01	0.13	0.02	0.01
May 15	0.01	0.01	<0.01	0.03	<0.01
Jun 03	0.04	0.07	0.18	0.06	0.05
Jun 17	0.14	0.13	0.18	0.19	0.16
Jul 02	0.05	0.05	0.20	0.06	0.06
Jul 15	0.05	0.06	0.13	0.09	0.12
Aug 07	0.02	0.03	0.14	0.11	0.05
Aug 21	0.06	0.06	0.05	0.10	0.06
Sep 04	0.01	0.01	0.20	0.11	0.01
Sep 18	0.01	0.02	0.13	0.06	0.02
Oct 02	0.05	0.04	0.18	0.08	0.06
Oct 16	<0.01	<0.01	0.01	<0.01	<0.01
Nov 05	0.01	0.01	0.03	0.05	0.01
Nov 19	<0.01	0.01	0.03	<0.01	<0.01
Dec 10	0.08	0.17	0.04	0.09	0.08
Dec 18	0.17	0.15	0.07	0.15	0.15

*Sampling accident

Table 18

Nitrate (mg/L-N) Values from the Cedar River
Near the Duane Arnold Energy Center During 1985

	Sampling Locations				
Date 1985	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
Jan 08	6.8	7.0	6.8	7.2	6.7
Jan 24	5.9	5.8	6.6	6.3	6.1
Feb 04	5.7	5.7	4.1	5.5	5.7
Feb 18	5.2	5.2	*	5.1	5.2
Mar 06	4.4	4.2	4.3	4.2	4.3
Mar 18	5.2	5.2	3.8	5.2	5.3
Apr 03	6.2	6.2	3.0	6.2	6.3
Apr 15	6.4	6.4	0.5	6.6	6.5
May 01	7.3	7.3	0.4	7.1	7.2
May 15	4.3	4.2	3.4	3.6	4.1
Jun 03	1.4	1.4	1.6	1.3	1.4
Jun 17	5.7	5.6	5.5	4.6	5.1
Jul 02	3.8	3.6	3.6	3.4	3.5
Jul 15	0.3	0.3	0.3	0.3	0.3
Aug 07	<0.1	<0.1	0.6	0.3	<0.1
Aug 21	0.2	0.1	0.4	0.3	0.2
Sep 04	0.6	0.6	2.1	1.0	0.8
Sep 18	1.9	1.8	7.0	3.3	2.2
Oct 02	5.7	5.6	13.0	7.6	5.7
Oct 16	8.0	8.1	8.1	8.0	8.0
Nov 05	7.1	7.0	11.0	7.9	7.3
Nov 19	7.6	7.5	15.0	8.3	8.0
Dec 10	7.8	10.0	16.0	8.5	8.1
Dec 18	7.4	7.5	8.9	8.4	7.8

*Laboratory accident.

Table 19

Total Iron (mg/L) Values from the Cedar River
Near the Duane Arnold Energy Center During 1985

	Sampling Locations				
Date 1985	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
Jan 08	0.33	*	0.30	0.25	0.35
Jan 24	*	0.17	0.09	0.21	0.21
Feb 04	1.7	0.37	0.12	0.23	0.24
Feb 18	0.26	0.37	0.58	0.27	0.27
Mar 06	4.6	5.2	4.3	4.7	4.8
Mar 18	0.81	0.81	1.5	1.9	1.1
Apr 03	0.80	0.88	0.26	0.84	0.84
Apr 15	1.1	1.0	0.36	1.0	1.0
May 01	1.1	1.0	0.53	0.93	0.58
May 15	0.58	0.51	0.53	0.50	0.41
Jun 03	0.76	0.76	0.55	0.72	0.37
Jun 17	1.0	0.72	0.62	0.65	0.83
Jul 02	0.44	0.59	0.80	0.74	0.53
Jul 15	0.30	0.28	0.68	0.31	0.17
Aug 07	0.37	0.30	0.74	0.46	0.40
Aug 21	0.36	0.32	1.2	0.73	0.40
Sep 04	0.76	0.75	1.6	1.0	0.95
Sep 18	0.68	0.40	1.2	0.70	0.49
Oct 02	0.71	0.69	1.8	0.84	0.56
Oct 16	0.95	0.94	0.94	1.0	0.93
Nov 05	0.51	0.50	0.99	0.59	0.55
Nov 19	0.43	0.41	1.1	0.59	0.55
Dec 10	0.13	0.10	0.50	0.12	0.06
Dec 18	0.12	0.10	0.26	0.20	0.20

*Sampling accident.

Table 20

Biochemical Oxygen Demand (5-Day) Values from the Cedar River
Near the Duane Arnold Energy Center During 1985

Date 1985	Sampling Locations				
	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
Jan 08	1	*	1	1	1
Jan 24	*	1	<1	1	<1
Feb 04	2	1	<1	1	1
Feb 18	<1	<1	1	1	<1
Mar 06	8	7	7	7	7
Mar 18	3	4	2	3	3
Apr 03	3	3	3	4	4
Apr 15	4	3	9	3	4
May 01	4	5	2	4	4
May 15	7	7	6	7	7
Jun 03	17	20	13	16	18
Jun 17	8	9	7	8	9
Jul 02	12	14	10	12	12
Jul 15	13	14	11	12	12
Aug 07	15	16	15	14	14
Aug 21	16	27	23	18	21
Sep 04	12	14	19	16	13
Sep 18	13	15	17	14	13
Oct 02	4	4	8	5	4
Oct 16	3	3	3	3	3
Nov 05	3	3	3	6	3
Nov 19	3	3	3	3	3
Dec 10	2	2	2	1	1
Dec 18	<1	1	2	2	1

*Sampling accident

Table 21

Coliform Bacteria (Total, org/100 ml) Values from the Cedar River Near the Duane Arnold Energy Center During 1985

Date 1985	Sampling Locations: Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
Jan 08	2,100	2,000	900	800	900
Jan 24	*	14,000	700	9,000	19,000
Feb 04	4,300	3,400	120	4,300	2,100
Feb 18	16,000	3,400	2,900	2,100	2,100
Mar 06	14,000	3,300	2,400	2,800	4,000
Mar 18	1,500	1,100	1,800	1,500	1,300
Apr 03	1,500	1,100	10	1,200	1,000
Apr 15	200	500	100	1,000	800
May 01	300	300	300	100	400
May 15	600	100	500	1,300	200
Jun 03	<100	700	100	100	<100
Jun 17	800	1,100	200	800	500
Jul 02	100	70	1,000	1,000	1,000
Jul 15	300	130	600	400	60
Aug 07	20	<10	*	*	< 10
Aug 21	600	50	<10	200	*
Sep 04	*	*	700	1,000	400
Sep 18	*	500	700	500	300
Oct 02	3,000	8,000	4,000	4,000	700
Oct 16	100	3,000	1,600	700	1,200
Nov 05	2,200	1,400	2,100	2,100	1,600
Nov 19	2,300	1,600	5,000	1,700	2,100
Dec 10	1,700	800	800	1,000	1,000
Dec 18	1,500	1,400	300	1,700	1,500

*Sampling accident.

Table 22

Coliform Bacteria (Fecal, org/100 ml) Values from the Cedar River Near the Duane Arnold Energy Center During 1985

Date 1985	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
	Sampling Locations				
Jan 08	200	250	60	70	50
Jan 24	*	3800	130	3600	3100
Feb 04	2500	1400	<10	1100	1200
Feb 18	520	310	140	330	380
Mar 06	900	880	660	750	800
Mar 18	250	90	60	200	230
Apr 03	170	70	10	110	110
Apr 15	50	40	10	30	40
May 01	50	70	10	30	30
May 15	60	50	10	80	50
Jun 03	50	50	40	90	20
Jun 17	70	130	40	70	100
Jul 02	30	10	50	20	30
Jul 15	70	100	10	20	10
Aug 07	400	40	2000	*	40
Aug 21	1000	200	100	900	*
Sep 04	*	*	700	*	100
Sep 18	30	*	300	100	100
Oct 02	610	500	600	700	490
Oct 16	400	230	100	*	200
Nov 05	90	90	300	80	90
Nov 19	250	200	200	150	170
Dec 10	170	110	130	140	160
Dec 18	350	230	30	370	250

*Sampling accident

Table 23

Quarterly Chemical Analysis - 1985

	Station	Cr	Cu	Pb	Mn	Hg	Zn	Cl^- (mg/L)	SO_4^{-2} (mg/L)
		Metals (µg/L)							
	February 4								
1.	Lewis Access	<10	<10	<10	860	<1	50	25	53
2.	Upstream DAEC	<10	<10	<10	40	<1	10	25	52
3.	Downstream DAEC	<10	<10	<10	30	<1	10	24	52
4.	½ Mile Below Plant	<10	<10	<10	20	<1	10	24	54
5.	Discharge Canal	<10	<10	<10	20	<1	10	90	96
	May 1								
1.	Lewis Access	<10	<10	<10	140	<1	<10	22	25
2.	Upstream DAEC	<10	<10	<10	120	<1	<10	24	31
3.	Downstream DAEC	<10	<10	<10	130	<1	<10	23	26
4.	½ Mile Below Plant	<10	<10	<10	140	<1	<10	22	28
5.	Discharge Canal	<10	<10	<10	80	<1	<10	4	15
	July 15								
1.	Lewis Access	<10	<10	<10	140	<1	40	22	21
2.	Upstream DAEC	<10	<10	<10	130	<1	40	22	42
3.	Downstream DAEC	<10	<10	<10	130	<1	30	20	41
4.	½ Mile Below Plant	<10	<10	<10	110	<1	80	21	41
5.	Discharge Canal	<10	<10	<10	210	<1	40	19	38
	October 2								
1.	Lewis Access	<10	<10	<10	950	<1	<10	22	35
2.	Upstream DAEC	<10	<10	<10	120	<1	<10	22	39
3.	Downstream DAEC	<10	<10	<10	170	<1	<10	27	120
4.	½ Mile Below Plant	<10	<10	<10	110	<1	<10	23	60
5.	Discharge Canal	<10	20	<10	320	<1	20	62	580

Table 24

Benthic Macroinvertebrates
Collected from the Cedar River and Discharge Canal near the Duane Arnold Energy Center
Summer 1985

TAXON	ARTIFICIAL SUBSTRATE COLLECTION Lewis Access A	B	C	U/S of Station A	B	C	140' D/S A	B	C	½ mile D/S A	B	C	Discharge Canal A	B	C	PONAR GRAB COLLECTIC U/S of Station	140' D/S
Tricoptera																	
Hydropsyche sp.	2	--	--	2	1	--	--	--	--	--	--	--	--	--	4	--	--
Hydropsyche biddens	87	94	91	93	80	56	55	63	54	55	33	40	2	--	1	--	--
Hydropsyche orris	201	233	212	324	379	384	294	326	329	198	157	82	--	1	1	--	--
Hydropsyche simulans	18	26	21	57	52	36	38	27	32	35	29	18	--	2	1	--	--
Potamyia flava	49	54	31	9	9	14	29	31	24	16	32	44	3	2	5	--	--
Diptera																	
Chironomidae larvae	71	167	183	64	57	88	94	126	155	364	213	224	316	350	324	--	--
Chironomidae pupae	10	27	34	9	4	5	5	21	20	31	17	27	12	11	16	--	--
Simulium sp. - larvae	--	2	--	--	--	1	--	--	--	--	--	--	2	0	2	--	--
Simulium sp. - pupae	1	1	--	--	--	--	--	--	--	--	--	--	41	28	20	--	--
Ephemeroptera																	
Baetis sp.	--	3	2	1	2	2	1	5	2	3	7	--	3	2	9	--	--
Caenis sp.	--	1	1	--	4	--	--	1	2	4	--	--	3	--	--	--	--
Isonychia sp.	1	5	--	65	46	47	14	31	19	44	38	22	14	16	31	--	--
Tricorythodes sp.	--	2	3	--	--	1	--	6	3	1	--	3	--	--	--	--	--
Heptagenia flavescens	--	--	--	1	--	1	--	--	--	--	--	--	1	--	--	--	--
Stenonema sp.	2	2	2	--	--	1	1	2	1	2	--	1	7	3	1	--	--
Stenonema exiguum	--	1	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--
Stenonema integrum	--	--	--	--	1	1	--	--	1	1	--	--	1	1	2	--	--
Stenonema puchellum	--	1	--	--	1	5	1	2	--	--	2	--	--	--	1	--	--
Stenonema terminatum	--	3	1	1	5	7	5	13	3	4	4	1	18	19	23	--	--
Plecoptera																	
Pteronarcys sp.	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--
																--	--
Coleoptera																	
Lara sp. larvae	1	--	--	1	2	1	2	--	--	--	--	--	--	--	--	--	--
Stenelmis sp. -adult	1	3	4	1	25	20	--	3	6	1	--	1	--	--	--	--	--
Stenelmis sp. -larvae	1	1	4	4	4	5	--	--	--	--	--	--	1	--	1	--	--
Amphipoda																	
Gammarus sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	4	12	--	--

Table 24 cont.

Benthic Macroinvertebrates
Collected from the Cedar River and Discharge Canal near the Duane Arnold Energy Center
Summer 1985

	ARTIFICIAL SUBSTRATE COLLECTION															PONAR GRAB COLLECTI(	
	Lewis Access			U/S of Station			140' D/S			½ mile D/S			Discharge Canal			U/S of Station	140' D/S
TAXON	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C		
ɜopoda																	
Asellus sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--
astropoda																	
Physa sp.	--	--	--	--	--	--	--	--	--	--	--	--	98	33	97	--	--
irudinea																	
Mooreobdella sp.	--	--	--	--	--	--	--	--	--	--	--	--	6	27	40	--	--
Total No. of Organisms	445	626	509	633	671	675	540	657	651	759	532	463	528	499	592	0	0
Total No. of Species	13	18	13	15	16	18	13	14	14	14	10	11	16	15	20	0	0

IOTE: To convert actual organisms counted to No./M^2 multiply by 5.69

Table 24 cont.

Benthic Macroinvertebrates
Collected from the Cedar River and Discharge Canal near the Duane Arnold Energy Center
Fall 1985

TAXON	ARTIFICIAL SUBSTRATE COLLECTION															PONAR GRAB COLLECTI[illegible]	
	Lewis Access			U/S of Station			140' D/S			½ mile D/S			Discharge Canal			U/S of Station	140' D/S
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C		
Tricoptera																	
Hydropsyche sp.	9	5		1	--	4	--	7	4				1	--	--	--	--
Hydropsyche biddens	84	47		48	87	63	32	53	29				1	1	6	--	--
Hydropsyche orris	190	97		216	200	327	116	229	183				1	1	43	--	--
Hydropsyche simulans	33	28		16	25	32	5	21	32				--	--	--	--	--
Potamyia flava	94	62		54	91	108	60	96	192				2	2	21	--	--
Symphitopsyche morsa	--	--		--	--	--	--	--	1				--	--	--		
Diptera																	
Chironomidae larvae	25	20		37	8	35	8	74	13				808	878	864	3	--
Chironomidae pupae	1	--		3	1	--	--	1	--				22	11	21	--	--
Simulium sp. - larvae	11	1		10	12	13	11	6	2				--	--	--	--	--
Simulium sp. - pupae	9	1		26	2	8	36	7	3				--	--	--	--	--
Ephemeroptera																	
Baetis sp.	--	1		--	--	--	--	--	1				--	--	--	--	--
Caenis sp.	--	--		--	--	--	--	1	--				--	--	--	--	--
Isonychia sp.	3	--		--	--	--	--	--	--				--	--	1	--	--
Stenonema sp.	2	4		9	3	1	6	1	1				--	--	1	--	--
Stenonema puchellum	1	3		--	--	--	--	2	--				--	--	--	--	--
Stenonema integrum	1	--		1	--	--	--	--	--				--	--	--	--	--
Stenonema terminatum	5	3		3	--	2	4	3	--				--	--	--	--	--
Potamanthus sp.	--	--		--	--	1	--	--	--				--	--	--	--	--
Plecoptera																	
Perlodidae	--	2		--	--	--	1	--	--				--	--	--	--	--
																--	--
Odonata																	
Argia sp.	--	--		--	--	--	--	--	--				13	14	14	--	--
Coleoptera																	
Lara sp. larvae	--	--		1	1	--	--	1	3				--	--	--	--	--
Stenelmis sp. -larvae	3	1		8	1	1	--	3	6				--	--	--	--	--
Stenelmis sp. -adult	2	2		1	1	5	--	3	4				--	--	1	--	--
Helichus sp. -adult	--	--		--	--	--	--	1	--				--	--	--	--	--

Table 24 cont.

Benthic Macroinvertebrates
Collected from the Cedar River and Discharge Canal near the Duane Arnold Energy Center
Fall 1985

	ARTIFICIAL SUBSTRATE COLLECTION															PONAR GRAB COLLECTIC	
	Lewis Access			U/S of Station			140' D/S			½ mile D/S			Discharge Canal			U/S of Station	140' D/S
TAXON	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C		
Gastropoda																	
Physa sp.	--	--		--	--	--	--	--	--				2	--	7	--	--
Hirudinea																	
Mooreobdella sp.	--	--		--	--	--	--	--	--				15	7	16	--	--
Megaloptera																	
Corydalus sp.	--	1		--	--	--	--	1	--				--	--	--	--	--
Total No. of Organisms	473	278		434	432	600	279	510	474				865	914	995	3	0
Total No. of Species	16	16		15	12	13	10	18	14				9	7	11	1	0

NOTE: To convert actual organisms counted to No./M^2 multiply by 5.69

Table 25

Daily Numbers of Fish Impinged at the
Duane Arnold Energy Center, January - December 1985

Day of the Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	2	3	0	0	0	1	0	0	0	4	0	0
2	4	2	0	0	0	0	0	0	0	14	1	0
3	2	3	4	0	0	0	0	2	0	7	2	1
4	1	2	0	0	0	0	0	0	0	3	0	0
5	5	2	0	0	0	0	0	2	1	0	13	0
6	1	0	0	0	0	0	0	0	1	4	10	7
7	0	0	0	0	0	0	0	0	0	0	6	1
8	3	0	0	0	0	0	0	0	0	2	90	3
9	2	2	2	0	0	0	0	1	0	1	60	1
10	2	5	0	0	0	0	0	0	0	0	22	6
11	1	1	0	0	0	0	0	0	0	2	24	1
12	2	1	0	0	0	0	0	0	0	0	23	1
13	2	0	1	0	0	0	0	1	0	2	20	0
14	1	0	0	0	0	0	0	0	0	3	15	2
15	1	0	0	0	0	0	0	0	1	3	19	1
16	0	0	0	0	0	0	1	1	0	0	0	0
17	3	10	0	0	0	0	0	0	0	2	7	0
18	3	7	0	0	0	0	1	1	0	1	11	2
19	6	3	0	0	0	0	0	1	1	1	14	0
20	6	12	0	0	0	0	1	0	0	0	11	1
21	2	4	1	0	0	0	0	0	2	1	28	2
22	3	11	3	0	0	0	0	0	7	1	9	2
23	1	5	0	0	0	0	1	0	0	0	14	12
24	5	5	0	0	0	0	1	1	3	0	11	2
25	2	3	0	0	0	0	0	0	7	0	16	4
26	4	3	0	0	0	0	0	2	7	0	14	6
27	3	0	0	0	0	0	0	0	1	0	4	2
28	2	2	0	0	0	0	0	1	0	0	7	0
29	2	-	0	0	0	0	0	1	2	0	3	4
30	0	-	2	0	0	0	0	0	0	0	0	0
31	2	-	0	-	0	-	2	0	-	2	-	0
Total	73	86	13	0	0	1	7	14	33	53	454	61

Annual Total - 795

Table 26

Comparison of Average Yearly Values for Several Parameters in the Cedar River Upstream from the Duane Arnold Energy Center*
1972-1985

Year	Mean Flow (cfs)	Turbidity (NTU)	Total PO_4 (mg/L)	Ammonia (mg/L-N)	Nitrate (mg/L-N)	BOD5 (mg/L)
1972	4,418	22	1.10	0.56	0.23	5.7
1973	7,900	28	0.84	0.36	1.5	4.0
1974	5,580	29	2.10	0.17	4.2	4.7
1975	4,206	58	1.08	0.33	2.8	6.5
1976	2,082	41	0.25	0.25	2.8	7.3
1977	1,393	15	0.33	0.52	2.9	6.5
1978	3,709	23	0.26	0.22	4.4	3.3
1979	7,041	26	0.29	0.12	6.6	2.5
1980	4,523	40	0.34	0.19	5.4	4.3
1981	3,610	33	0.77	0.24	6.0	6.5
1982	7,252	43	0.56	0.23	8.0	5.1
1983	8,912	22	0.25	0.10	8.6	3.3
1984	7,325	40	0.32	0.10	5.9	3.9
1985	3,250	30	0.31	0.11	4.8	6.7

*Data from Lewis Access location (Station 1).

Table 27

Summary of Relative Loading Values (Average Annual Concentration x Cumulative Runoff) for Several Parameters in the Cedar River Upstream of the Duane Arnold Energy Center*
1972-1985

Year	Mean Flow	Cumulative Runoff (in.)	Turbidity	Relative Loading Values			
				Total PO_4	Ammonia	Nitrate	BOD_5
1972	4,418	9.24	203	10.2	5.2	2	53
1973	7,900	16.48	461	13.8	5.9	25	66
1974	5,580	11.64	338	24.4	2.0	49	55
1975	4,206	8.77	509	9.5	2.9	25	57
1976	2,082	4.35	178	1.1	1.1	12	32
1977	1,393	2.91	44	1.0	1.5	8	19
1978	3,709	7.74	178	2.0	1.7	34	26
1979	7,041	14.79	385	4.3	1.8	98	37
1980	4,523	9.45	378	3.2	1.8	51	41
1981	3,610	7.53	248	5.8	1.8	45	49
1982	7,252	15.13	651	8.5	3.5	121	77
1983	8,912	18.00	396	4.5	1.8	155	59
1984	7,325	15.22	609	4.9	1.5	90	59
1985	3,250	6.80	204	2.1	0.8	33	46

*Data from Lewis Access location (Station 1)

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